Appendix D

Description of Quality Indicator Calculation

Steps Used In Validation QI Calculation

This chapter outlines the processing steps used to calculate raw and adjusted QIs for the mega QI Validation Task using the 4th quarter of 2001 (2001Q4) and the 1st quarter of 2002 (2002Q1) as the target periods. The processing steps were as follows:

1. **Obtain all MDS records from CMS for 1998, 1999, 2000, 2001 and 2002 through Quarter 1 (2002Q1).**
2. **Select QI calculation samples.**
   - **2.1. Select 6 Chronic Care (CC) QI calculation samples for 6 target quarters: 2000Q2, 2000Q3, 2000Q4, 2001Q1, 2001Q4 and 2002Q1. The first four samples, based on a simple random sample of 10% of facilities, will be used to build logistic regression models; the fifth and sixth samples, using data from all facilities, will be used for reporting.**
     - 2.1.1. Selection based on the specifications in the record selection document.
     - 2.1.2. Selection is by resident.
     - 2.1.3. Selection is for the entire nation.
     - 2.1.4. Each resident in a sample has the following CC records selected:
       - 2.1.4.1. A target assessment (most recent) in the target quarter.
       - 2.1.4.2. A prior assessment preceding target assessment if available.
       - 2.1.4.3. An assessment preceding the prior assessment if available
       - 2.1.4.4. A most recent full assessment if available.
   - **2.2. Select 6 Post Acute Care (PAC) QI calculation samples for 6 target quarters: 2000Q2, 2000Q3, 2000Q4, 2001Q1, 2001Q4 and 2002Q1. The first four samples, based on a simple random sample of 10% of facilities, will be used to build logistic regression models; the fifth and sixth samples, using data from all facilities, will be used for reporting.**
     - 2.2.1. Selection based on the specifications in the record selection document.
     - 2.2.2. Selection is by resident.
     - 2.2.3. Selection is for the entire nation.
     - 2.2.4. Each resident in a sample has the following PAC records selected:
       - 2.2.4.1. A 14-day SNF PPS assessment (most recent) in the target quarter and preceding quarter.
       - 2.2.4.2. A 5-day SNF PPS assessment from the same stay if available.
       - 2.2.4.3. A recent admission assessment if available.
3. **Create a resident-level QI calculation file for each of the 6 target quarters. The resident-level QI calculation file for a target quarter has 1 record for every resident in either the CC QI calculation sample or the PAC QI calculation sample for that quarter. Each record contains variables corresponding to the 7 assessments which could potentially be selected for each resident:**
   - 3.1. A CC target assessment (most recent) in the target quarter.
   - 3.2. A CC prior assessment preceding target assessment if available.
   - 3.3. A CC assessment preceding the prior assessment if available.
   - 3.4. A CC most recent full assessment if available.
   - 3.5. A PAC 14-day SNF PPS assessment (most recent) in the target quarter and preceding quarter.
   - 3.6. A PAC 5-day SNF PPS assessment from the same stay if available.
   - 3.7. A recent admission assessment if available.

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4. Calculate resident-level QI scores and covariate scores for each resident in each of the 6 target quarters and store the resulting values in the resident-level QI calculation files for each of the 6 target quarters.

4.1. For each CC and PAC QI separately.

4.1.1. **Resident-level QI calculation.** For each resident for a target quarter, determine if the resident should be excluded from QI calculation. The exclusion rules for QI calculation are given for each CC and PAC QI in the QI operational definitions matrix.

4.1.1.1. If the resident is excluded, then store a missing value for that QI in the resident-level QI calculation record appropriate to that resident for a target quarter.

4.1.2. If the resident is not excluded, determine if the resident triggers the QI (is to be included in the QI numerator). The triggering (numerator) rules for QI calculation are given for each CC and PAC QI in the QI operational definitions matrix.

4.1.2.1.1. If the resident triggers the QI, then store a value of 1 for that QI in the resident-level QI calculation record appropriate to that resident for a target quarter.

4.1.2.1.2. If the resident does not trigger the QI, then store a value of 0 for that QI in the resident-level QI calculation record appropriate to that resident for a target quarter.

4.1.3. **Resident-level covariate calculation.** For each covariate associated with the QI.

4.1.4. For each resident for a target quarter, determine if the resident should be excluded from covariate calculation. The exclusion rules for covariate are given for each CC and PAC QI in the QI operational definitions matrix.

4.1.4.1.1. If the resident is excluded, then store a missing value for that covariate in the resident-level QI calculation record appropriate to that resident for a target quarter.

4.1.5. If the resident is not excluded, determine if the resident triggers the covariate (value 1). The triggering rules for covariate calculation are given for each CC and PAC QI in the QI operational definitions matrix.

4.1.5.1.1.1.1. If the resident triggers the covariate, then store a value of 1 for that covariate in the resident-level QI calculation record appropriate to that resident for a target quarter.

4.1.5.1.1.1.2. If the resident does not trigger the covariate, then store a value of 0 for that covariate in the resident-level QI calculation record appropriate to that resident for a target quarter.

5. At this point, the resident-level QI calculation file for each of the 6 target quarters has a score for each QI and for each covariate associated with a QI.

6. Select Facility Admission Profile (FAP) calculation samples.

6.1. Select 6 Chronic Care (CC) FAP calculation samples for 6 target quarters: 2000Q2, 2000Q3, 2000Q4, 2001Q1, 2001Q4 and 2002Q1. The first four

samples will be used to build logistic regression models; the fifth and sixth samples will be used for reporting.

6.1.1. Selection based on the specifications in the record selection document.
6.1.2. Selection is by resident.
6.1.3. Selection is for the entire nation.
6.1.4. Each resident in a sample has the following CC record selected:
6.1.4.1. The most recent admission assessment in the year ending with the target quarter.

6.2. Select 6 Post Acute Care (PAC) FAP calculation samples for 6 target quarters: 2000Q2, 2000Q3, 2000Q4, 2001Q1, 2001Q4 and 2002Q1. The first four samples will be used to build logistic regression models; the fifth and sixth samples will be used for reporting.

6.2.1. Selection based on the specifications in record selection document.
6.2.2. Selection is by resident.
6.2.3. Selection is for the entire nation.
6.2.4. Each resident in a sample has the following PAC record selected:
6.2.4.1. The most recent PPS 5-day assessment in the year ending with the target quarter.

7. Create a resident-level FAP calculation file for each of the 6 target quarters. The resident-level FAP calculation file for a target quarter has 1 record for every resident in that FAP sample and contains variables from the admission assessment (CC) or PPS 5-day assessment (PAC) which was selected for that resident.

8. Calculate resident-level FAP scores for each resident in each of the 6 target quarters and store the resulting values in the resident-level FAP calculation files for each of the 6 target quarters.

8.1. For each CC and PAC FAP separately.
8.1.1. **Resident-level FAP calculation.** For each resident in a target quarter, determine if the resident should be excluded from FAP calculation. The exclusion rules for FAP calculation are given for each CC and PAC QI in the QI operational definitions matrix.
8.1.1.1. If the resident is excluded, then store a missing value for that FAP in the resident-level FAP calculation record appropriate to that resident for a target quarter.
8.1.2. If the resident is not excluded, calculate the resident-level FAP score according to the rules for FAP calculation given for each CC and PAC QI in the QI operational definitions matrix and store the calculated value for that FAP in the resident-level FAP calculation record appropriate to that resident for a target quarter.
8.1.2.1.1. If the FAP is a prevalence measure with numerator and denominator defined, then the FAP score will be a 1 if the numerator conditions are satisfied and a 0 otherwise.
8.1.2.1.2. If the FAP is based on a scale, then the FAP score is the computed scale score.

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9. Create a facility-level output file for each facility for each of the 6 target quarters. The facility-level output file for a target quarter has 1 record for each facility in the universe of facilities.

10. Calculate facility-level FAP scores for each facility for each of the 6 target quarters and store the resulting values in the facility-level output files for each of the 6 target quarters.

10.1. For each CC and PAC FAP separately.

10.1.1. **Facility-level FAP calculation.** Compute the average FAP values for a QI for each facility for each of the 6 target quarters.

10.1.1.1. Store the resulting averages in the facility-level output record for each facility for each of the 6 target quarters.

10.1.1.2. A facility-level FAP result for one of the target quarters is missing if there are no residents in the corresponding resident-level calculation file for the target quarter

11. At this point, the facility-level output file for each of the 6 target quarters has mean values for each FAP for each QI.

12. For each of the five target periods, replicate the facility-level FAP mean for each FAP for each CC QI and each PAC QI into the resident-level QI calculation records for all residents within a facility.

13. At this point, the resident-level QI calculation file for each of the 6 target quarters has resident-level values for each CC and PAC QI, resident-level values for each covariate associated with a QI, and the facility-level mean FAP value for the FAP associated with each QI.

14. A pooled resident-level QI calculation file is created by combining all resident-level QI calculation records from the 4 files for the 2000Q2, 2000Q3, 2000Q4 and 2001Q1 target quarters. This pooled resident file is used to build logistic regression models to predict each QI.

15. The SAS logistic regression procedure is then run to obtain a logistic model for each CC QI and PAC QI to predict the resident-level QI score from the facility-level FAP and resident-level covariates (if any) associated with a QI. The pooled data from the first four target quarters (2000Q2, 2000Q3, 2000Q4, and 2001Q1) are used to build these models.

15.1. Input data file is the pooled resident-level QI calculation file (across the 4 target quarters).

15.2. Dependent variable is the resident-level QI score.

15.3. Predictors are the facility-level FAP (if specified) and the resident-level covariates (if any).

15.4. Output values are the logistic regression coefficients for each QI. The coefficients for each QI include a constant, a FAP coefficient (if applicable), and a coefficient for each covariate (if applicable).

16. The logistic model coefficients from the pooled resident-level QI calculation sample are then used to calculated expected QI scores for each CC QI and PAC QI for each resident for the fifth (2001Q4) and sixth (2002Q1) target quarters.

16.1. The formula used for this calculation is given in the description of the expected score QI calculation.

16.2. For each QI, the input data for this calculation are the facility-level FAP and resident-level covariate scores (if applicable) from the resident level QI calculation file, as well as the logistic coefficients from Step 16.

16.3. The expected QI scores for each QI for each resident are stored in the resident-level QI calculation file for the 2001Q4 and 2002Q1 target quarters.

17. Calculate the overall mean observed QI rate for the 2001Q4 and 2002Q1 target quarters across all states.

17.1. For each CC and PAC QI separately.

17.1.1. Overall mean observed QI rate calculation.

17.1.1.1. For each resident with non-missing data on the QI score (not excluded) in the resident-level QI calculation file for 2001Q4 and 2002Q1 (across all states):

17.1.1.1.1. Count the total number of these residents and retain the result as the overall QI denominator count across all states.

17.1.1.1.2. Count the total number of these residents triggering the QI (QI score of 1) and retain the result as the overall QI numerator count across all states.

17.1.1.2. Divide the overall QI numerator by the overall QI denominator and retain the result as the overall observed QI rate.

18. Calculate facility-level observed QI rate and facility-level expected QI rate for each facility for the 2001Q4 and 2002Q1 target quarter and store the resulting values in the facility-level output file for that target quarter.

18.1. For each CC and PAC QI separately.

18.1.1. **Facility-level observed QI and expected QI rate calculation.**

18.1.1.1. For each resident in the facility with non-missing data on the QI score (not excluded) and on all covariate scores (if applicable):

18.1.1.1.1. Count the total number of these residents in the facility and store the result in the facility-level output record as the QI denominator count for the facility.

18.1.1.1.2. Count the total number of these residents triggering the QI (QI score of 1) and store the result in the facility-level output record as the QI numerator count for the facility.

18.1.1.1.3. Average the expected QI score for all of these residents and store in the facility-level output table as the expected QI rate for the facility.

18.1.1.2. Divide the facility-level QI numerator by the facility-level QI denominator and store the result in the facility-level output record as the observed QI rate.

19. Calculate facility-level adjusted QI score for each facility for the 2001Q4 and 2002Q1 target quarters and store the resulting value in the facility-level output file for that target quarter.

19.1. For each CC and PAC QI separately.

19.1.1. **Facility-level adjusted QI score calculation.**

19.2. The formula for this calculation is given in description of the adjusted score QI calculation.

19.2.1.1.1. For each QI, the input data for this calculation are the facility-level observed and expected QI rates from the facility output table, as well as the overall observed QI rate from Step 17.

19.2.1.1.2. The adjusted QI score for each QI for each facility is stored in the facility output file for 2001Q4 and 2002Q1.

19.2.1.1.3. The adjusted QI score will be missing if either the facility-level observed QI rate or the facility-level expected QI rate is missing.

Calculation of the Expected QI Score

The resident-level expected QI score for a QI is an estimate of the risk that a resident will trigger the QI. This risk estimate is based on consideration of:

1. The facility-level admission and assessment practices of the facility, as measured by the Facility Admission Profile (FAP) for the QI, if specified.
2. The resident-level covariates associated with the QI if specified.

(It should be noted that a few of the QIs do not have an adjustment model in the specifications; these QIs will not have an expected or adjusted score.)

The expected score for many of the QIs considers the facility-level FAP defined for the QI. The facility-level FAP for a QI is the facility average of the resident-level FAP scores based on the most recent admission assessment a resident in the last 12 months. The rules for resident-level FAP calculation are given for each CC and PAC QI in the QI operational definitions matrix.

Note that the FAP sample is based upon all admissions during a 12-month period and contains residents who may not be included in any of the individual QI samples (although there will be overlap). Furthermore, note that each facility-level FAP score is replicated for all residents associated with a facility. Thus for a particular QI, the FAP score is a constant for all residents associated with a given facility in the QI's logistic regression model.

For some QIs, the expected QI score considers resident-level covariates associated with the QI; such QIs may or may not also consider the facility-level FAP covariate. For other QIs, resident-level covariates are not considered and the expected QI score is based solely on the FAP. The QI operational definitions matrix presents the resident-level covariates (if any) associated with each QI and the logic for calculating each covariate.

For each QI, a resident-level logistic regression equation for the expected score has been statistically derived from analysis of a pooled sample of all residents from a 10 percent random sample of all facilities for four target quarters: Quarter 2 of 2000 (2000Q2) through Quarter 1 of 2001 (2001Q1). These logistic regression equations were derived using the resident-level QI score as the dependent variable. The predictor variables were the facility-level FAP and any resident-level covariates associated with the QI.

The resulting logistic regression equations are of the form:

$$\frac{1}{1 + e^{-X}}$$

Where e is the base of natural logarithms and X is a linear combination of the logistic regression coefficients and the predictor variables of the form:

Calculation of the Expected QI Score

$$C_0 + C_{FAP}*FAP + C_1*COV_A + C_2*COV_B + \ldots$$

Where C_0 is the logistic regression constant, C_{FAP} is the logistic regression coefficient for the Facility Admission Profile (where applicable), FAP is the facility-level Facility Admission Profile score for the resident's facility (where applicable), C_1 is the logistic regression coefficient for the first covariate (where applicable), COVA is the resident-level score for the first covariate (where applicable), C_2 is the logistic regression coefficient for the second covariate (where applicable), and COV_B is the resident-level score for the second covariate (where applicable).

For each QI, such a logistic regression equation is applied to each resident and the result is the resident-level expected score for the QI.

As an example, consider the actual calculation used for the expected score for the CC "Percent of Residents with Pressure Sores with FAP Adjustment" QI (PRU01). This QI does not consider any resident covariates (only the FAP is considered) and the actual equation used was:

$$\frac{1}{1 + e^{-(-2.72659 + 2.21735*F\_CPRU1)}}$$

Where F_CPRU1 is the facility-level FAP for PRU01.

The PAC "Percent of Short-Stay Residents with Delirium with FAP Adjustment" QI (PAC_DEL0X) provides an example of a QI that considers a FAP variable and a resident-level covariate. The covariate for that QI is lack of prior residential history in a nursing home, residential care facility, or MH/MR facility. The equation used for this QI was:

$$\frac{1}{1 + e^{-(-3.65433 + 7.26925*F\_DEL0X - 0.22714*ResHist)}}$$

Where F_DEL0X is the facility-level FAP for DEL0X and ResHist is the resident-level covariate indicating lack of prior residential history.

The CC "Percent of Residents with Pain" QI (PAI0X) provides an example of a QI that considers only a resident-level covariate. The covariate for that QI is an indicator of independence in daily decision-making on the prior assessment. The equation used for this QI was:

Calculation of the Expected QI Score

$$\frac{1}{1 + e^{-(-2.49156 + 0.86520 * \text{IndpDec})}}$$

Where IndpDec is the resident-level covariate indicating independence in daily decision-making.

Calculation of the Adjusted QI Score

The adjusted QI score is a facility-level QI adjusted for the specific risk for that QI in the facility. The risk-adjusted QI score can be thought of as estimate of the facility's QI rate if the facility had residents with average risk.

The facility-level adjusted score is calculated on the basis of the facility-level observed QI rate, the facility-level average expected QI rate, and the national average observed QI rate.

The actual calculation of the adjusted score uses the following equation:

$$Adj = \frac{1}{1 + e^{-\left[\mathrm{Ln}\left(\frac{Obs}{(1-Obs)}\right) - \mathrm{Ln}\left(\frac{Exp}{(1-Exp)}\right) + \mathrm{Ln}\left(\frac{Nat}{(1-Nat)}\right)\right]}}$$

Where **Adj** is the facility-level adjusted QI score, **Obs** is the facility-level observed QI rate, **Exp** is the facility-level expected QI rate, **Nat** is the national observed QI rate, and **Ln** indicates a natural logarithm.

Note that the observed QI rate (**Obs**) is modified in two special cases before applying the equation:

1. When **Obs** equals 0, then **Obs** is reset as follows before using in the equation:

$$Obs = \frac{1}{(4 * QI\_den)}$$

   where QI_den is the observed QI denominator value (number of residents).

2. When **Obs** equals 1, then Obs is reset as follows before using in the equation:

$$Obs = 1 - \frac{1}{(4 * QI\_den)}$$

   where QI_den is the observed QI denominator value (number of residents).

The adjusted score equation will produce adjusted scores in the range of 0 to 1. These adjusted scores can then be converted to percentages for ease of interpretation.

These adjusted score calculations are applied to QIs that use expected scores based on the Facility Admission Profile (FAP) and/or resident-level covariates.